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ABSTRACT

Over decades, a number of researchers in science curriculum and science teaching and learning have pointed out that the history of science plays a pivotal role in the achievement of science literacy. However, recent studies have shown that both practitioners and textbook writers often fail to deal with subjects such as history and philosophy of science. In this study, we describe and analyze the elaboration of a history of science teaching strategy, as part of a four book set designed by the authors for middle school science course. Inspired by Wandersee & Roach's Interactive Historical Vignettes (IHVs) (In: Mintzes, Wandersee & Novak, Teaching Science For Understanding, 1998), which, in turn, is partially informed by conceptual change theory, the strategy comprises a set of eight role-play activities (two per grade, one semester), focusing on scientists whose work brought decisive contributions to the worldwide scientific knowledge. The tasks, which include the scientists' biographical information, script, costumes, and stage setting, are supposed to be done by the students under the tutelage of the science teacher or of a multidisciplinary team. To provide the necessary support for both children's and teacher's work, some guidelines are offered, as well as basic bibliography. The critical analysis that, just like the Interactive Historical Vignettes, the role- play strategy offers a significant contribution in order to facilitate the achievement of a better understanding of the nature of science, both by students and teachers, especially because scientists are shown as human beings who live, work, and study in a real context. Thus, science appears less mystified and less mythologized. Considering that throughout the Brazilian territory there is a lack of textbooks in which the subject "history of science" is dealt with in a suitable way, the roleplay strategy, as described and analyzed in this study, can be considered an innovative enterprise. Consequently, our final conclusion is that our study contributes significantly either to basic education science teachers (primary, middle and high schools) or researchers of the academic area concerned about science literacy. (Author)

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ROLEPLAYS IN MIDDLE SCHOOL SCIENCE TEXTBOOKS: A SIGNIFICANT CONTRIBUTION TO THE HISTORY OF SCIENCE TEACHING

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Abstract

Over decades, a number of researchers in science curriculum and science teaching and learning have pointed out that the history of science plays a pivotal role in the achievement of science literacy. However, recent studies have shown that both practitioners and textbook writers often fail to deal with subjects such as history and philosophy of science. In this study, we describe and analyse the elaboration of a history of science teaching strategy, as part of a four book set designed by the authors for middle school science course.

Inspired by Wandersee & Roach's Interactive Historical Vignettes (IHVs) (In: Mintzes, Wandersee & Novak, *Teaching science for understanding*, 1998), which, in turn, is partially informed by conceptual change theory, the strategy comprises a set of eight roleplay activities (two per grade, one per semester), focusing on scientists whose work brought decisive contributions to the worldwide scientific knowledge. The tasks, which include the scientists' biographical information, script, costumes, and stage setting, are supposed to be done by the students under the tutelage of the science teacher or of a multidisciplinary team. To provide the necessary support for both children's and teacher's work, some guidelines are offered, as well as basic bibliography.

The critical analysis suggests that, just like the Interactive Historical Vignettes, the roleplay strategy offers a significant contribution in order to facilitate the achievement of a better understanding of the nature of science, both by students and teachers, especially because scientists are shown as human beings who live, work, and study in a real context. Thus, science appears less mystified and less mythologized. Considering that throughout the Brazilian territory there is a lack of textbooks in which the subject "history of science" is dealt with in a suitable way, the roleplay strategy, as described and analysed in this study, can be considered an innovative enterprise. Consequently, our final conclusion is that our study contributes significantly either to basic education science teachers (primary, middle and high schools) or researchers of the academic area concerned about science literacy.

Introduction

The history of science plays a pivotal role in the achievement of science literacy, especially because it helps to enhance the meaningfulness and comprehension of science content in the context of the nature of science (Wandersee & Roach In: Mintzes, Wandersee & Novak, *Teaching science for understanding*, 1998). Despite of that, practitioners and textbook writers have been failing to deal with subjects related to history and philosophy of science in a proper way. According to Bastos (In: Nardi, *Questões atuais no ensino de Ciências*, 1998) the history of science programs, either in high school, middle school or elementary school courses[1], show several problems such as: a) commiting raw factual mistakes; b) neglecting the relationship between the process of scientific knowledge production and the social, political, economic and cultural context; c) suggesting that scientific knowledge made progress solely by means of fantastic or fabulous discoveries carried out by genius scientists; d) glorifying the present and its paradigms, neglecting the importance of the scientific branches which diverge from the recent ones, the richness of the debates that took place in the past, the discontinuity between

[1] According to the Brazilian educational system: highschool = children aged 15-18; middle school = children aged 11-14, and elementary school = children aged 7-10.

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the past and the present, etc. and e) encouraging the belief in current scientific knowledge as a universal truth. This view is shared, at least in part, by Bizzo (1992), who points out that the attempts to evoke the history to enlighten the science teaching have generally been failing mainly because: a) our look to the past usually selects the elements that can explain the present, instead of trying to bring back the history of science, and b) the scientific theories proposed in the past are considered simple and ingenuous whereas the present ones are seen as complex and ingenious.

Bizzo (In: São Paulo, Secretaria de Estado da Educação. Coordenadoria de Estudos e Normas Pedagógicas. *Ensino de Biologia: dos fundamentos à prática*, 1996) also claims that these problems result of a science's amputation from the body of the history. Once separated, or as the author says, divorced from the history, science generated and gave birth to a child called "scientific knowledge neutrality". In other words, knowledge was removed from its historical context, losing a big part of its sense (Bizzo In: São Paulo, Secretaria de Estado da Educação. Coordenadoria de Estudos e Normas Pedagógicas, *Ensino de Biologia: dos fundamentos à prática*, 1996). These claims are in accordance with Chassot (1995) who has pointed out the absence of history as a constant bad habit of our science teaching. According to this author, there are very few teachers concerned in electing history as the backbone of their courses. Chassot also stresses the importance of dealing with the uncertainty as well as showing the students how different models are built in science and why, eventually, some of them are abandoned while others are modified. It is important, he completes, to recognize how different events have contributed to the gradual building of models.

Therefore, the big task that challenges the science teaching programs is to reintegrate science to its historical context, by electing history of science basically in two ways: a) as a teaching content itself, and b) as a source of inspiration to define the contents and to propose teaching strategies (Bastos In: Nardi, *Questões atuais no ensino de Ciências*, 1998). Whatever the choice is, the author warns that it is necessary to produce as well as to evaluate curriculum and support material.

Interactive Historical Vignettes And History Of Science Teaching: Principles, Construction And Application

Wandersee & Roach (In: Mintzes, Wandersee & Novak, *Teaching science for understanding*, 1998) have proposed an approach to history of science teaching based on the belief that scientific world view, as part of nature of science, can be provided by "relevant examples of scientists who demonstrated it via their life histories". Called Interactive Historical Vignettes (IHVs), Wandersee & Roach's approach employs little science stories easier and quicker to read and tell. Actually, each IHV consists of a small and carefully chosen part or "slice" of the history of science designed and used to illustrate a single aspect of the nature of science. In order to achieve its aims, the IHV must be presented in an interactive way, taking only 10-15 minutes of the class time. Once a week, without fail, a new IHV must be designed, so the students can be constantly in contact with different pivotal cases or incidents in a certain scientist's life throughout the science course.

The first step to design an IHV is the reading of histories of science about the life of a given scientist. The second step consists in choosing an intellectual or behavioral choicepoint of a pivotal incident in the scientist's life. Once the choice is made, it is necessary to decide which attribute of the nature of science is epitomized by the selected incident. In the fourth step, an Interactive Historical Vignette is written using the following format: a) introduction to the scientist; b) context and basis of the incident; c) choicepoint and sample options; d) final outcome of the incident. The final version of the IHV is then written in docudrama style. The total presentation time must be 5 minutes maximum. The fifth step is the IHV presentation in docudrama style. It starts with the presentation of the first three parts of the vignette to the class. The students are then given some time to decide, independently, what choice the scientist focused in the vignette eventually made. After the students' answers, the fourth and last part of the vignette is told. The next step is a class discussion about current science applications of the nature of science attribute they have learned by the IHV (Wandersee & Roach In: Mintzes, Wandersee & Novak, *Teaching science for understanding*, 1998).

Although the teacher is the most appropriate person to design and apply an IHV, especially in the begining of the science course, Wandersee & Roach (In: Mintzes, Wandersee & Novak, *Teaching science for understanding*,

1998) have noticed that, after the first month of activities, it is suitable to ask the students to design their own vignettes. However, the teacher must be aware that the students need a technical support, which includes a list of sources of the information needed and systematic assistance, the latter supposing to be given from the first to the last step of the IHV construction.

Interactive Historical Vignettes strategy is partially informed by "conceptual change theory" by which learning is considered an interactive process instead of a simple accumulation of data (Wandersee & Roach In: Mintzes, Wandersee & Novak, *Teaching science for understanding*, 1998). Consequently, it is absolutely necessary that the learner actively engage in revising his or her ideas when confronted by different ones. It is important to bear in mind that, according to the conceptual change theory, the learner has a conceptual structure by which he or she explains the world. So, it is exactly in the conceptual structure the learner's ideas are embedded. Considering that new ideas are constantly interacting with the past experiences, the learner's conceptual structure is continually changing. As these changes go on, a number of rearrangements of existing conceptual structures may happen and contribute to form, elaborate and integrate the new ideas. The result of this process is an increase of understanding (Wandersee & Roach In: Mintzes, Wandersee & Novak, *Teaching science for understanding*, 1998).

Roleplays In Science Textbooks: Towards A Nature Of Science Understanding

Artistic creation, as well as scientific research, is among the activities that occupy the highest levels of meaningful learning (Novak In: Mintzes, Wandersee & Novak, *Teaching science for understanding*, 1998; Moreira, *Aprendizagem significativa*, 1999). It is important to emphasize that "meaningful learning theory" has a close relationship with the "conceptual change theory". Firstly because , just like the latter, the "meaningful learning theory" considers learning as an active process that underlies the constructive integration between thought, feeling and action which, in turn, leads to the human empowerment (Moreira, *Aprendizagem significativa*, 1999). Secondly because there is a number of authors who have contributed to the creation of both theories, suggesting a common origin for them.

So this is how the roleplay in science textbooks strategy rises : informed by "meaningful learning theory" and inspired in Wandersee and Roach's Intercative Historical Vignettes. The approach comprises a set of eight roleplays activities two per grade, one per semester each one focusing on a given important name whose work brought decisive contributions to the worldwide scientific knowledge. The names in focus are: for the 5th grade, Jules Verne[2] and Ernst Haeckel; for the 6th grade, Robert Hooke and Georges Leclerc (Count of Buffon); for 7th grade, Gregor Mendel and Joseph Priestley and, for the 8th grade, Blaise Pascal and Edwin Hubble. The choice of these names is the result of a careful selection which took into consideration mainly two aspects: a) the relevance of the scientist as a nature of science representative, and b) the connection between the scientist and the contents developed throughout a given unit[3] or chapter.

The students work in groups under the tutelage of the science teacher, especially on those tasks related to collecting and selecting information about the scientist, as well as those related to script writing. It is also possible to organize a single big play, performed by one entire class or a big group composed by students of more than one class. In that case, it is suitable that the play becomes a school project, so the students must be tutored by a multidisciplinary team.

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[2] Even though Jules Verne has not been a scientist, his name was included among the personalities in focus because of his undeniable importance in the scientific field, especially as a science divulger. The age in which Jules Verne lived is known by its plentiful and significant scientific and technological progresses, which influenced Verne's writing style considerably. The teachers were properly informed that such context, that is, the scientific progresses and their effects to people's lives and thought, should be stressed throughout the roleplay construction.

[3] For the purposes of the work reported in this text, a unit is a group of three, four or five chapters, depending on the case.

Following the book set layout, the roleplay construction task is presented to the students in a section especially designed for that purpose. Called *Vista a camisa*[4], the section has a heading which identifies it in the textbook. Immediately after the heading, the students are informed who the scientist in focus is.

Guidelines to the students

After beeing informed who the scientist in focus in the section is, the students are given some guidelines in order to provide them the support needed. The first group of guidelines includes the following items: a) period of time in which the scientist[5] lived; b) country(ies) in which he or she spent his/her life; c) main aspects of the age in which the scientist lived; d) how these aspects influenced his/her life; e) how his/her life was before, during and after he/she became a researcher; f) what kind of researches he/she carried out, and g) which impacts those reasearches brought up to the world.

In the second group of guidelines, students can find instructions which can help them to construct the play. The instructions are: a) select all the information they consider relevant; b) organize meetings to decide how many and who will be the characters of the play; c) write the script; d) design the costumes and the stage setting; e) rehearse the play, trying to correct the eventual mistakes, and f) make the presentation.

Guidelines to the teachers

The book set includes a teacher's book which comprises three parts. The first one is an introduction, where the teacher can find the educational principles of the book set as well as a brief description of the sections that can be found in the chapters, including the section *Vista a camisa*. Thus, thanks to this first part of the teacher's book, the teacher is given an overview of the section aims, as well as some hints on play designing. Among these hints there are some suggestions recommending the use of modest and/or domestic material such as worn out clothes, old textile and board paper to produce masks, clothes and other objects. The importance of the philosophical, social and economic aspects of the period in which the scientist spent his/her life is also emphasized here.

The second part of the teacher's book contains a widely detailed description of the chapters, one by one, section by section. Here, everytime the section *Vista a camisa* appears, a group of contextual and biographical information is offered, providing the basic data the teacher needs to plan and start his/her work successfully.

Finally, there is a third part of the teacher's book which contains a basic bibliography.

Besides the guidelines mentioned and described above, bi-annual meetings are organized by the publishing company in order to offer the teachers opportunities to obtain some extra information directly from the authors, as well as to share experiences among each other.

Discussion

The science book set in which the roleplay strategy was proposed is quite new. Since the book set publishing, in 2001, the authors had only three meetings with the teachers, two of them dedicated to present the principles and aims of the book set. Due to this, the authors have very few data about the real impacts, in classroom work, of the roleplay strategy as it has originally been proposed. However, thanks to the oral reports offered by the teachers, as well as the theory that supports both the book set designing and the study described in this article, it is possible to bring out some important aspects.

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[4] Literally, this expression means "wear the shirt". As a Brazilian idiomatic expression, "Vista a camisa" is usually employed with the meaning of "go for it", "engage". Naming the section reported in this article, "Vista a camisa" means "be in someone else's shoes".

[5] In the textbook, we employ the term "researcher" instead of "scientist". Our aim is to show the scientist as a human being with a special interest in studying nature's phenomena, by means of the scientific research. It is our belief that this procedure contributes to defeat the mistaken view which considers the scientist as a genius.

Multidisciplinary work
Teachers are not used to work in teams. Depending on the way the roleplay is designed, the roleplay strategy gives the teachers the opportunity to work in a multidisciplinary team, that is, a group of work composed by teaching professionals of different areas, such as History, Arts, Geography, Portuguese, and obviously Science.

Interdisciplinary work
The interdisciplinary approach is the result of a principle according to which there is no way of knowledge that can be considered self-sufficient. Thus, the interdisciplinary thought recognizes the need of estimulating a kind of dialogue among other sources of knowledge, including the commom sense. Therefore, the interdisciplinary approach depends basically on a change of attitude in the presence of knowledge matter or, in other words, on the replacement of a fragmentary conception about the human being by a unitary one (Fazenda, *Interdisciplinaridade: um projeto em parceria*, 1991).

If applied according to the principles and guidelines included in the student's textbook, as well as in the teacher's book, the roleplay strategy may offer the science teacher a rich opportunity to develop an interdisciplinary work, especially if he or she is the only person responsible for the students' tutelage. In the authors' point of view, the challenge of tutoring the students by him/herself may create the favourable environment the teacher needs to start working in an interdisciplinary way. Even if the work is carried out by a multidisciplinary team, it is still possible to do it in an interdisciplinary way. In both cases, there is a number of elements that can influence the teacher's or the team's decision, and this is something the textbook and the authors are not able to predict or change.

Nature of science understanding
As described before, the roleplay strategy has been designed to show scientists as human beings who live, work, and study in a real context. By the way, the context is constantly valued in the guidelines, sometimes much more than the scientist him/herself. In doing so, the authors have the intention of stressing the influences the social, economic, political and cultural environment had in the scientist's private life and work. Considering that such an approach can help science to be shown less mystified and less mythologized, it is fair to conclude that the roleplay strategy offers a significant contribution in order to facilitate the achievement of a better nature of science understanding.

Innovative enterprise
Innovation has a considerable variety of meanings. For the purposes of this study, the authors have chosen Goldberg & Franco's definition, according to which innovation is a planned and scientific process of developing and establishing, in an educational system, a change which has a few possibilities of occurrence but, at the same time, has effects that bring a real improvement to the system (Goldberg & Franco, *Inovação educacional: um projeto controlado por avaliação e pesquisa*, 1980).

Considering that throughout the Brazilian territory there is a lack of science textbooks in which the subject "history of science" is dealt with in a suitable way, the roleplay strategy, as described and analysed in this study, can be considered an innovatory enterprise. Consequently, our final conclusion is that our study contributes significantly either to basic education science teachers (primary, middle and high schools) or researchers of the academic area concerned about science literacy.

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